Advanced Deep Space System Development Program

FIRST DELIVERY

David Woerner

NASA/Jet Propulsion Laboratory

david.f.woerner@jpl.nasa.gov

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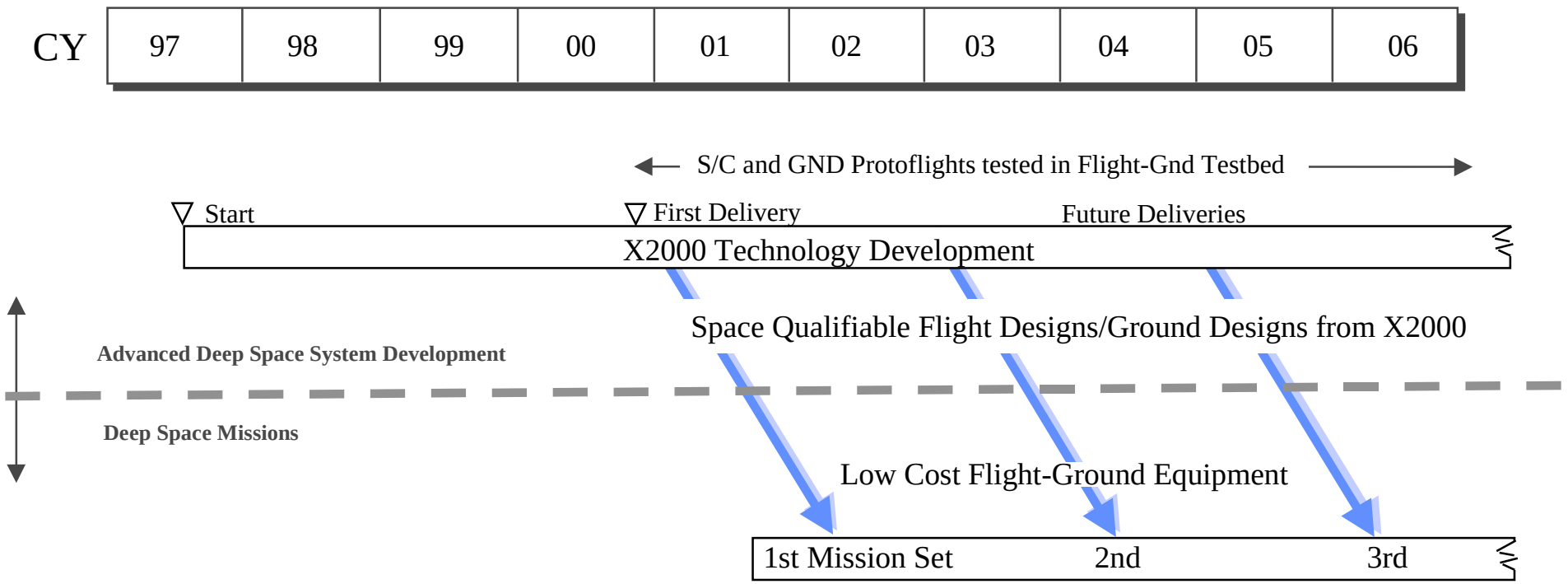
Flow of Advanced Deep Space System Development Deliveries

X2000



Users:
- Europa Orbiter
- Pluto-Kuiper Express
- Solar Probe
- Champollion
- Mars Sample Return Earth Return, Rendezvous, and Comm Orbiter Vehicles,

Potential Users:
- DS-3, SIM, Other Mars Program
- Comet Nucleus Sample Return
- Possible SEC, Discovery Missions, other.....

SEC = Sun Earth Connection **GND=** Ground **S/C**= Spacecraft **DS**-3= Deep Space 3 **SIM**=Space Interferometry Mission

Advanced Deep Space System Development
1st Delivery

X2000

AN INTEGRATED and QUALIFIED engineering model FLIGHT and GROUND SYSTEM

- Flight System Micro-electronics
  - Computer and memory
    - Neural Network
    - Digital Signal Processor
  - Power & Pyro Switching
  - Sensor/Instrument I/O
  - Scaleable, modular, long life
  - RAD Hardened Designs and Parts
  - Low Temperature, low power
  - X and Ka Band Comm
  - Optical Comm -- Possible
- F/S and GND S/W with W.S:
  - Operating systems
  - Generic auto NAV, 3-Axis A/C
  - Generic F/S-GND autonomy
  - Generic F/S-GND science data processing
  - Generic GND CMD/TLM processing/display
- ARPS power source
- Other: Micro-electronic components, structure, thermal, propulsion, etc. as budget allows

GND = Ground **W.S.** = Work Station **A/C** = Attitude Control **I/O** = Input/Output Interface
F/S = Flight System **S/W** = Software **CMD** = Command **TLM** = Telemetry **ARPS** = Advanced Radioisotope Power Source

Flight System Summary

An Example for a Europa Orbiter

X2000

- Science
  - Radar sounder, LIDAR, mult. spec. WAC & MAC
- Telecom
  - Redundant Optical Com/NAC/Laser Alt receiver
  - Single DSTT with X-band SSPA & MGA
- Data System
  - 3D Stack MCM Computers (3)
  - Stacked memory Solid State Recorder
  - Multiple buses/variable power draw
- Power
  - 150 W. ARPS
  - Power & pyro switching microelectronics
- Attitude Control
  - 3 axis stabilized
  - Adv. Stellar Compass w/CPU
  - Solid state IMU
  - Sun sensors
- Propulsion
  - 400 N dual mode w/liquid regulators
  - 20 N TVC biprop thrusters
  - Monoprop 1 N and 5 mN RCS thrusters
- Temperature Control
  - ARPS waste heat
  - MLI blankets and louvers
  - RHU's
  - Electric heaters

Legend:
MCM - Multichip Module
MAC/NAC/WAC - Medium/Narrow/Wide Angle Camera
DSTT - Tiny Deep Space Transponder
ARPS - Advanced Radioisotope Power Source
MLI - Multi-layer insulation
RCS - Reaction Control System
IMU - Inertial Measurement Unit
RHU - Radioisotope Heater Unit

Performance

Pointing Control	2 mrad
Pointing Knowledge	1.5 mrad
Rate Control	<10 µrad/sec
Processor Speed	4-50 MHz
Data Bus Rate	50 Mb/sec
Data Storage	Redundant 16 Gb
Downlink (Optical)	~100 Kb/sec @Europa
Power	150 W @Europa
ΔV Capability	2.5 km/sec

Europa Orbiter Configuration
using an RF telecom system

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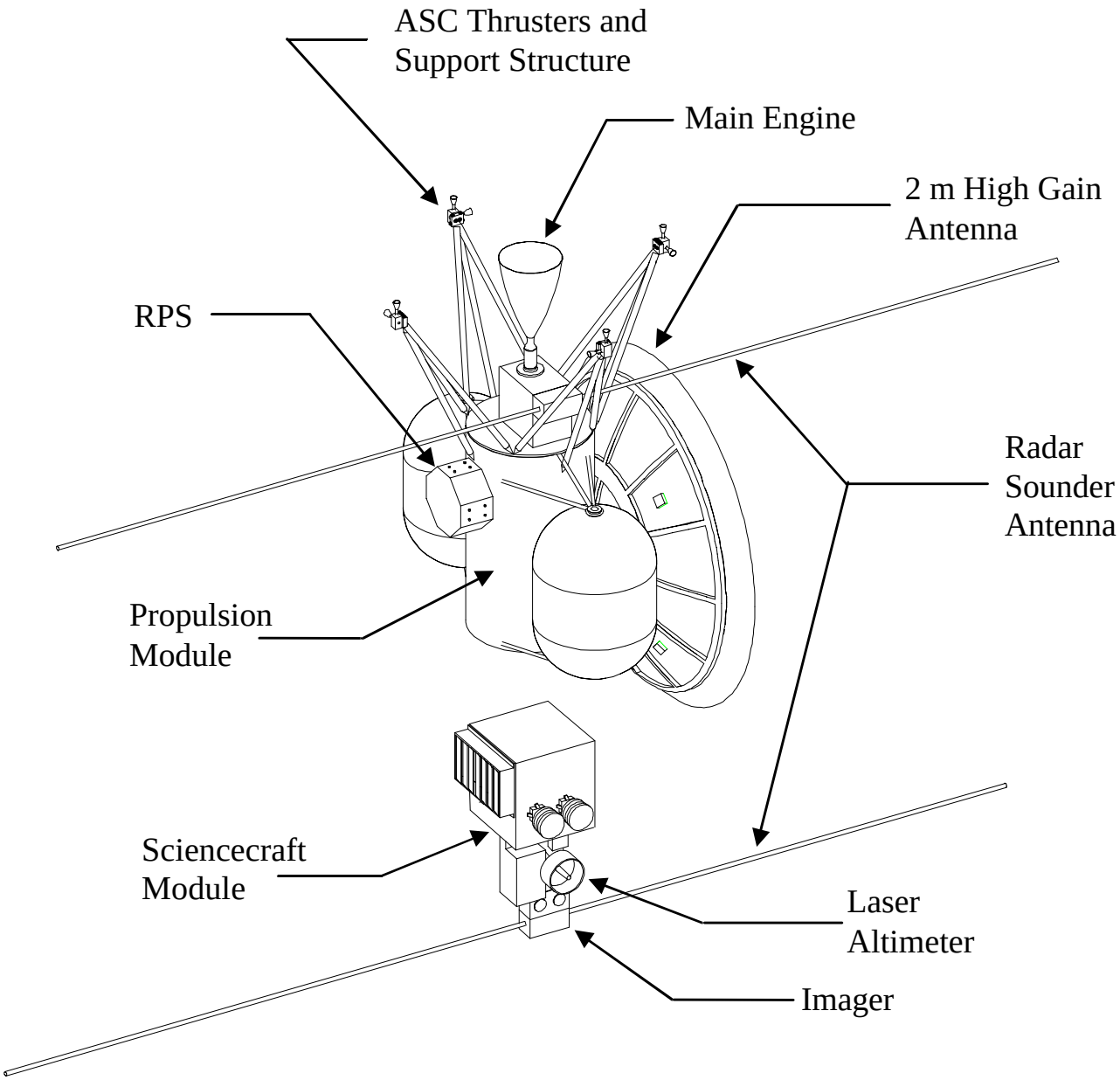

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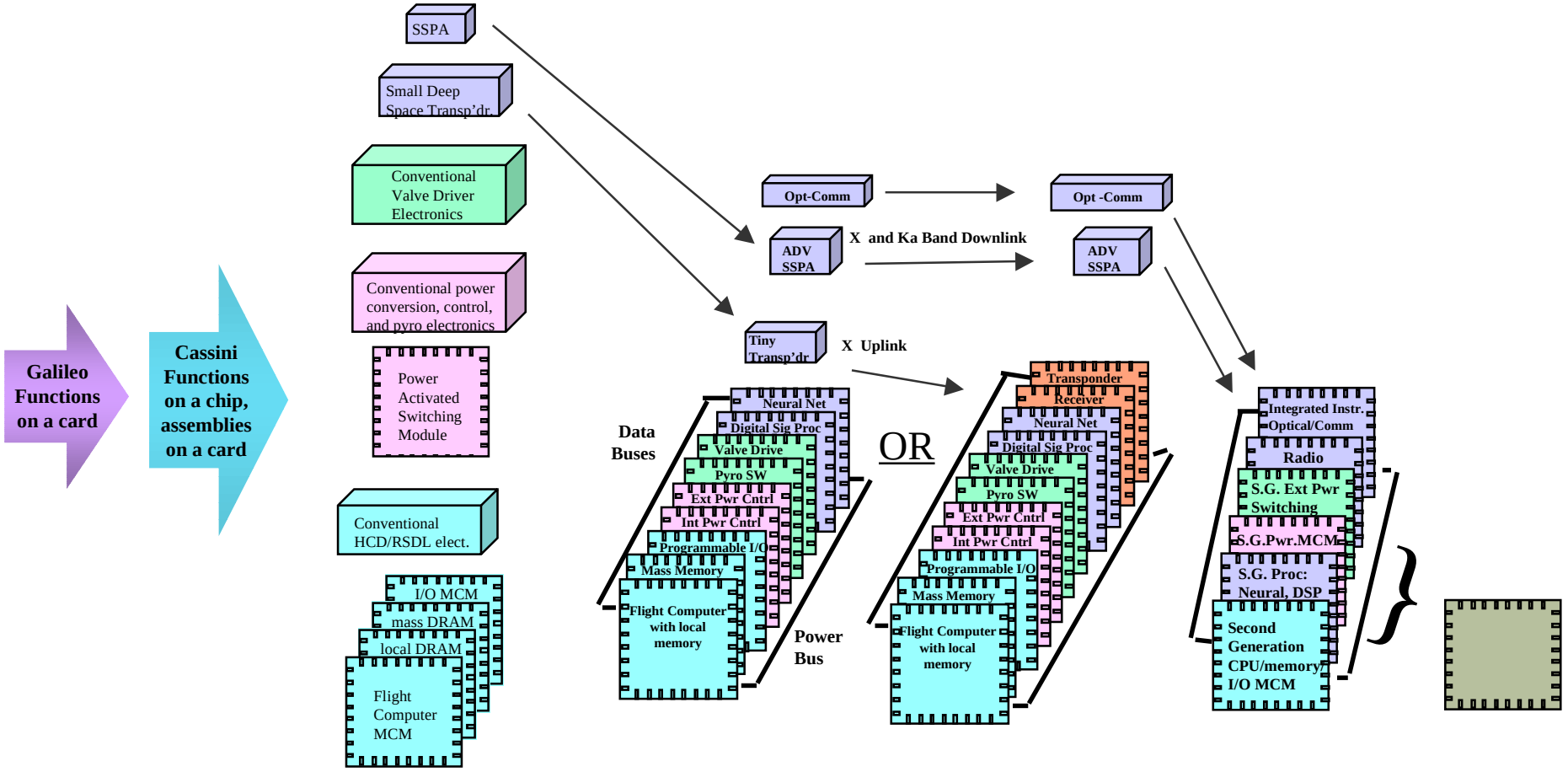


HCD/RSDL = Hardware Command Decoder/Need Solar Downlink **PWR** = Power
MCM = Multi-chip Modes **OPT** = Optical **SSPA** = Solid State Power Amplifier
NMP = New Millennium Program **DS1**= Deep Space 1, 1st NMP Technology Demo Flight

Technology Development and Insertion

X2000

- Microelectronics
  - 3D MCM Stacking
  - Integrates C&DH, Attitude Control, Telecom, and Power & Pyro Switching
  - Multifunctional Structure
  - HDI power electronics
  - Provides a general purpose scaleable processing environment, inc:
    - Digital Signal Processors
    - Multi-processor architecture
    - Neural Nets
- Advanced Radioisotope Power Source
- Software
  - Unified flight and ground system architecture, employing flight and ground autonomy, tasks readily transfered between ground and flight
  - On-board, distributed applications and processing
  - On-board planning of flight system activities and navigation
  - Software Implemented Fault Tolerance
  - Scaleable to mission needs; a general platform for mission to build upon

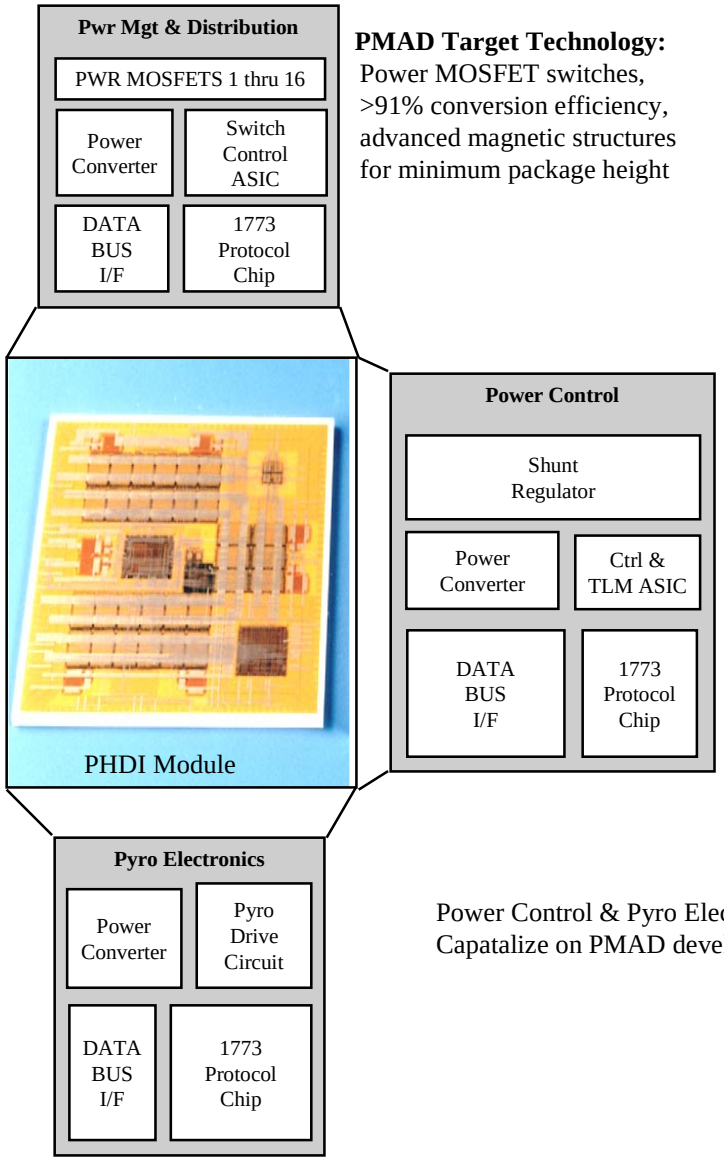
MCM - Multichip Module **HDI** - High Desity Interconnects **COTS** - Commercial-off-the-shelf
C&DH - Command & Data Handling

Technology Development and Insertion

X2000

- RF telecom
  - Transponder integrated with avionics
- Optical Communications
  - Comm Terminal capable of >100 kbps from Europa orbit
    - Also acts as laser altimeter receiver
    - Also acts as extremely high-resolution science imager
- Altitude control
  - Advanced Stellar Compass
- Propulsion
  - Hydrazine μthrusters
  - Variable liquid regulators
- Parts & Materials
  - Low voltage/power, rad hard electronic parts (≤ 3.3V for digital electronics)
  - Electronics parts list with radiation dose tolerances selectable by missions
  - Unshielded materials capable of withstanding radiation dose >25 Mrad
- Additional options
  - Next generation SEP
  - Optical processing

Power Microelectronics Technologies



PMAD Target Technology:
Power MOSFET switches, >91% conversion efficiency, advanced magnetic structures for minimum package height

Power Control & Pyro Electronics
Capatalize on PMAD development

Overview

Current Technology: PC Board packaging, discrete component control circuit, relay enable and command switches and SCR fire circuit for pyros

Target Technologies: 1. Mixed signal ASICs, 2. Power High Density Interconnect (PHDI) packaging, 3. modular fault tolerant design

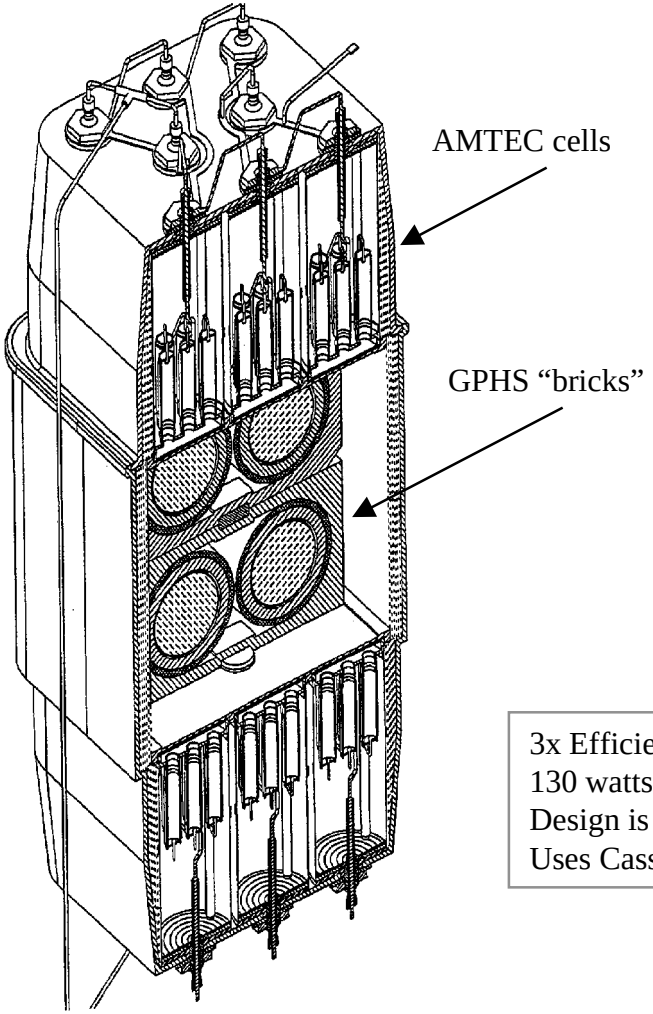
Benefits: 1. Reduce mass and volume, 2. standard command interface**,** 3. Provides peak power at maximum load, 4. configurable to various power source characteristics

Impact of Fallback: Several kg mass increase, increase in volume

Key Issues: Laser vs. NSI Pyro technology, thermal design, fault tolerant control circuit

PMAD - Power Management and Distribution

Advanced Radioisotope Power Source (ARPS) Technology



Overview

Current Technology: *Galileo/Cassini* heritage RTG with 6-7% efficiency unicouple conversion

Target Technology: >20% conversion using either AMTEC

Benefits: Mass reduction, smaller quantity of radioisotope

Key Issues:lifetime; efficiency; radiator size; heat rejection temperature

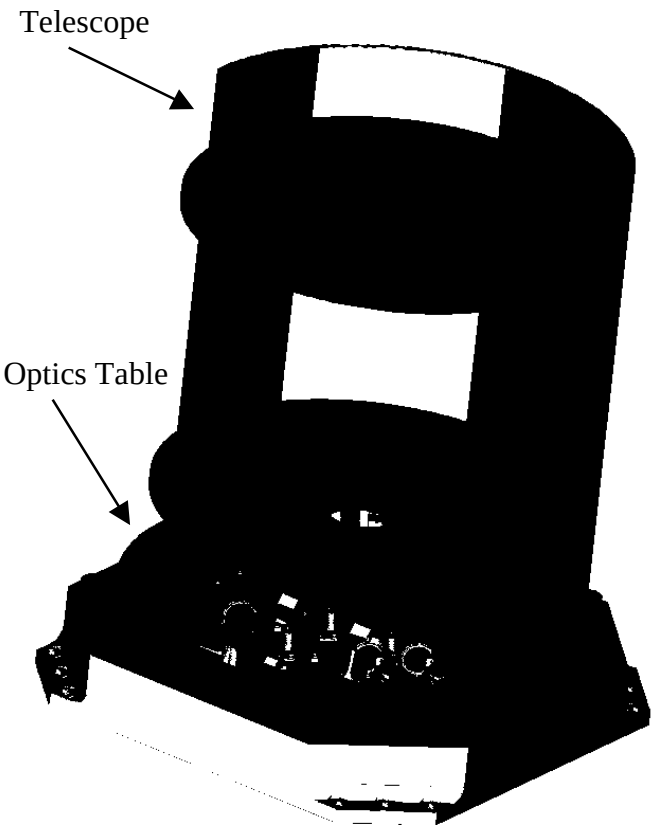
Impact of Fallback: > 12 kg mass increase

3x Efficiency over RTG's
130 watts after 15 yrs
Design is scaleable in 50W Units
Uses Cassini GPHS

GPHS = General Purpose Heat Source **RTG** = Radioisotope Thermoelectric Generator

AMTEC= A thermally regenerative electro--chemical device converting heat to electricity directly using a solid electrolyte. It is sealed and has no moving parts. Advanced Modular Power Systems (AMPS) is a small business licensed to develop these devices commercially.

Optical Communications Technology



Overview

Current Technology: X/Ka-band RF telecommunications systems

Target Technology: 30-cm optical comm terminal, uplink & downlink

Benefits: Dramatic increase in telemetry rate at mass and power levels equivalent to RF telecom system; see plot below

Key Issues:lifetime, system-level fault protection

Impact of Fallback: Reduction in science data returned